Clinical Outcomes After Spine Surgery for Traumatic Injury in the Octogenarian Population

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■ OBJECTIVE: **To review the surgical outcomes of the octogenarian population at a single institution after spinal traumatic injury.**

■ METHODS: **Patients with both radiographic and clinical evidence of acute traumatic spine injury were reviewed using an institutional trauma survey to determine patient demographics and outcome data in a population of patients aged 80 years and older.**

■ RESULTS: **Thirty-nine patients aged 80 years and older underwent surgical intervention for acute spinal trauma. There were 25 cases of cervical spine and 14 cases of thoracolumbar spine surgical intervention. Falls were the number one cause of acute spinal injury (31/39, 71%). Major respiratory disorders were the most common postoperative adverse event (12/39, 31%). Five patients experienced superficial wound dehiscence, fascial dehiscence, superficial infection, or delayed wound erosion. Patients were either discharged to home (10.5%), inpatient rehabilitation, (38.5%), skilled nursing facilities (17.9%), or long-term care facilities (17.9%). The post-operative mortality was 10.3%.**

■ CONCLUSIONS: **Although the octogenarian population has increased risk for postoperative events after acute spinal injuries, surgical intervention may be worthwhile in the elderly population. Although direct surgical complication rates are not higher, medical risks are significantly higher after surgery.**

INTRODUCTION

Between 1985 and 2010, the octogenarian population, defined as the population of people aged 80 years or older, more than doubled to 53 million in the developed world.[1] An aging population is further evident as life expectancy has become more prolonged, with children born in 2016 expected to live for an average of 78.6 years, an increase of 47 years compared with children born in 1900.[2] Regardless of sex and demography, with steady improvement in medical care, there has also been an increase in the functional capacity, activity level, and working years (retirement age) in the elderly population.

In an aging population, traumatic and unintentional injuries are particularly prevalent, as physiologic changes lead to a decreased ability to withstand traumatic injury. These changes include decreases in weight, body mass, and bone mass.[3] Furthermore, risk of traumatic injury related to unintentional injuries has risen to rank third in morbidity and mortality in the aging population, behind cancer and heart disease.[4]

In the past several years, there has been an interest in studying postoperative surgical outcomes after spinal surgery in the octogenarian population. Multiple studies have examined elective spinal operation outcomes in the elderly and have found good clinical outcomes with favorable complication rates in the octogenarian population, comparable to patients younger than 80 years, for both decompression only and fusion cases.[5-15] Although elective spinal operations are increasing in frequency, traumatic spinal injuries remain a separate demographic because of different medical comorbidities, as well as the presence of numerous other acute injuries or concomitant medical conditions. Given the complex balance of patient and family expectations for quality of life, functional and neurologic recovery, and pain versus the patient's overall medical health, surgeons often have a difficult time evaluating the risk/benefit ratio of operative versus nonoperative intervention in the acute setting.

Key words
- Complications
- Fusion
- Mortality
- Octogenarian
- Outcomes
- Spine
- Trauma

Abbreviations and Acronyms
ASIA: American Spinal Injury Association
SCI: Spinal Cord Injury

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Although there have been many studies examining elective spinal operation outcomes in the octogenarian population,[8,11,13-21] there are no available studies regarding the overall outcome for the most frequent traumatic spinal injuries in the cervical, thoracic, and lumbar spine. As practitioners in a level one trauma center, we manage elderly patients who have traumatic spinal injuries related to both motor vehicle accidents and activities of daily living. Thus, the elderly often have spinal fractures that are sometimes associated with neurologic deficit because of a combination of multiple chronic medical comorbidities, underlying osteopenia, osteoporosis, and multifactorial gait imbalance. This study aims to review the surgical outcomes of the octogenarian population at a single institution to add to the existing literature.

METHODS

An institutional trauma database was retrospectively reviewed for all patients with trauma with various cervical, thoracic, or lumbar injuries based on the Abbreviated Injury Scale from January 2011 to February 2018. Patients aged 80 years and older were identified based on their history of traumatic spinal injury and as a result underwent surgical decompression or instrumented stabilization using specific *International Statistical Classification of Diseases and Health Related Problems, Ninth Edition* and *Tenth Edition* codes to identify patients. Patients were selected by presenting with radiographic and clinical evidence of acute traumatic spine injury after documented recent trauma at the emergency department after initial admission. Radiographic inclusion criteria consisted of soft tissue (ligamentous) and/or bony injury or the presence of acute spinal cord or nerve root injury. Criteria for unstable spinal fractures included jumped or perched cervical facets, traumatic cervical disc herniation, 3-column thoracolumbar fractures, any fractures associated with significant translation or subluxation >3 mm, thoracolumbar burst fracture with >50% loss of height, 20° kyphotic angulation, 3 mm posterior fragment retropulsion, or any focal neurologic deficits resulting from cord compression secondary to the fracture or associated epidural hematoma.

In all cases, patients were admitted to the trauma service directly with the spine team after a consult service and underwent operative intervention within 72 hours of admission and more urgently when neurologic deficits were present. Of the 971 octogenarians identified in the institutional trauma registry, 39 patients who met inclusion criteria for operative intervention underwent surgery (median age, 83 years; range, 80–90 years). Basic demographic data, medical admission information, and trauma admission information (and assessment) were included for all patients. Institutional review board approval was obtained before initiation of this study.

Exclusion criteria for this study include patients with unstable spine fractures that failed initial conservative management (i.e., bracing), which required delayed, elective surgical intervention. We also excluded patients with minor reported falls or mild trauma who did not require activation of the trauma service and were subsequently admitted to the medicine or spine surgery service. Patients with cervical spondylotic myelopathy who presented with spinal cord injury (SCI) after fall without ligamentous or bony injuries on magnetic resonance imaging and unstable pathologic spinal fractures secondary to underlying neoplastic processes, infectious, or degenerative etiologies were also excluded from analysis.

Data parameters examined included basic demographic data and pertinent baseline chronic medical conditions, spine injury type and location, mechanism of injury, other associated traumatic injuries, indications for surgery, surgical levels and segments, postoperative surgical complications and adverse medical events, postoperative tracheostomy, discharge destination, postoperative neurologic and ambulatory status, surgical site wound issues, and postoperative mortality. Deceased patients either died during their in-hospital stay (as recorded by the trauma registry) or were confirmed dead by electronic medical record documentation after discharge. Available death certificates were reviewed to ascertain the cause of mortality. Furthermore, risk factor significance testing was completed using a Pearson χ^2 test and unpaired 2-sample Student *t* test (*P* value = 0.05).

RESULTS

Patient Demographics

Of the 4127 patients experiencing traumatic spine injury between January 1, 2011 and February 28, 2018, 971 were of the octogenarian population. Of these patients, 39 (14 women, 25 men) underwent spine surgery in an acute inpatient setting, with age ranging from 80 to 90 years (median, 83 years). Hypertension was the most common presenting medical comorbidity (69%; 27/39), whereas rib fracture was the most common secondary injury present (15%; 6/39). Patient demographics, medical comorbidities, and secondary injuries related to their trauma are summarized in Table 1.

Mechanism and Location of Injury

Falls accounted for 79% (31/39) of injuries in patients older than 80 years, 17 of which occurred at ground level, whereas 14 occurred after a fall from a height (i.e., steps or ledges). An additional 13% of patients (5/39) experienced injury after a motor vehicle accident and 8% (3/39) experienced falls off a ladder. Fractures were the most common injury morphology seen, because C1-C2 fractures were observed in 6 cases, C3-C7 fractures were observed in 8 cases, and thoracic or lumbar burst fractures were observed in 3 cases. Chance fractures occurred in 6 patients, and 3 patients had coexisting fracture-dislocation injuries.

Spinal segments operated on ranged from 1 to 7 levels, with a median (and mean) of 3 levels. The location and type of surgery performed on the patients can be found in Table 1.

Neurologic Status

The patients' neurologic status was recorded, with 44% of patients (17/39) presenting with American Spinal Injury Association (ASIA) score E and 54% (21/39) presenting with weakness or SCI. One patient withdrew to painful stimuli on presentation but had a concurrent middle cerebral artery stroke and did not have their ASIA score recorded. Specific ASIA scores are summarized in Table 1.

Of the patients presenting with neurologic deficits, 48% had a stable neurologic examination result at follow-up and 48% of patients had improved examination results. One patient had a worsening motor examination result at follow-up. In addition, 12 of the 23 patients (52%) who were followed up in clinic were ambulatory.

Postoperative Adverse Events

Postoperatively, there were no reported durotomy or pseudomeningocele, epidural hematoma, screw malpositioning, hardware failure, and pseudarthrosis. However, 2 patients (5%) had superficial wound dehiscence that was treated with either wet to dry dressing changes or a wound vac that was placed during a clinic encounter. Furthermore, 2 other patients (5%) had major wound issues, with 1 patient experiencing fascial dehiscence and 1 patient experiencing a superficial infection with wound drainage and erythema. One patient also had delayed wound erosion 5 years after a 3-level combined anteroposterior cervical fusion that was likely related to pronounced spinous process caused by progressive hyperkyphotic deformity of the cervicothoracic junction. Two patients with wound infections had hospital-acquired *Staphylococcus aureus*. No other organisms were identified in these 2 patients. Medical postoperative adverse events are summarized in **Table 1**.

Mortality and Follow-Up

Within the first 90 days after surgery, 8 patients died (median age, 82 years; range, 80—86 years). All cases occurred secondary to hypoxic respiratory failure. Six of the 8 mortalities were in-hospital, 4 of which had comfort measures only (days 5, 11, 12, and 19 in the postoperative period), 1 of which was a limited code (day 5 in the postoperative period), and 1 of whom died of pulseless electric activity arrest secondary to a large pulmonary embolus on day 8 of the postoperative period. Alternatively, 2 patients died within 30 days of surgery at an outside facility. Both of these patients required a tracheostomy and gastrostomy and were originally discharged to a long-term care facility. One of these patients was made a limited code during their inpatient stay and died 1 day after discharge whereas the other patient died 8 weeks after surgery. The exact cause of both of these patients' deaths was unclear based on existing medical records. All patients who had postoperative mortalities also had major preoperative comorbidities, concomitant acute traumatic injuries, and major postoperative events, which are outlined in **Table 1**.

Of the 39 patients who underwent surgical intervention, 59% were followed up in clinic (median follow-up, 4.5 months; range, 1—54 months), whereas 20.5% were lost to follow-up and 20.5% died within 90 days of their operation. Patient discharge disposition after their inpatient stay is summarized in **Table 1**.

DISCUSSION

Severity and Outcome Measures of Acute Spinal Injury

In the United States, the elderly population is predicted to increase 2—4 times its current population by 2060, with a considerable portion of those being 80 years of age or older.[22] Specifically, an analysis of all skeletal fractures by Amin et al.[23] showed that the overall incidence of fractures during 2009—2011 increased by 11% from 1989—1991, mainly driven by a 47% increase in thoracic and lumbar spine fractures between the 2 periods. Of significance, cervical spine and vertebral fractures increased among both men and women when adjusted for age; however, this was attributable to incidentally diagnosed vertebral fractures in patients older than 75 years.[23] Although little work has been carried out to assess outcomes and complications after fracture repair via surgery, postoperative complications and mortality are noted to be higher as age increases.[5,7,9,20,24-26] In addition, patients aged 18—64 years have significantly larger gains in ASIA motor score improvement over time than do injury-matched patients >65 years of age.[27] Although the geriatric population is at higher risk for SCI, Fassett et al.[6] found that geriatric patients show a greater percentage of ASIA grade C and D injuries, which were less severe than those of their younger cohort when examining cervical injuries. This finding may be related to the nature of central cord injury, which mechanically occurs after ground-level falls or striking the head and/or chin on the ground with the neck hyperextending. Fassett et al.[6] also found that, compared with geriatric populations, younger patients had an increased propensity to thoracolumbar and paraplegic injuries, which tends to be related to higher-velocity trauma compared with typical mechanisms of geriatric injury (falls secondary to cervical stenosis with concomitant multifactorial age-related changes). The present cohort correlates to the findings in the aforementioned study because 15 cervical SCIs were noted after falls, 10 of which occurred with a central cord syndrome presentation whereas 2 patients was classified as ASIA A. Compared with 6 thoracic SCI cases (4 of which presented with paraplegia), the present study may help support the increased incidence of cervical SCI compared with thoracic SCI in the octogenarian population. In the present cohort, an increased severity of neurologic deficits was not necessarily associated with wound issues ($P = 0.63$) or postoperative events ($P = 0.34$).

Complications

Complications in lumbar spinal surgeries for patients >65 years of age have been reported at rates of 3%—29%, with older age, comorbidities, blood loss, operative time, and number of levels acting as complicating factors.[13] In addition, the octogenarian population has an estimated complication rate of 20%, linked to the length of intensive care unit stay.[28] Although these studies primarily focus on lumbar surgeries, there has been no multicenter study in octogenarian patients with cervical and thoracic surgeries. In the present study, the rates of 29% for perioperative and 13% for major complications is similar to previous reports of lumbar surgeries. Conversely, overall medical complication rates are significantly higher in traumatic populations than are elective spinal surgeries (**Table 2**) for deep venous thrombosis/pulmonary embolus (10%), major respiratory events (31%), major cardiac issues (18%), respiratory failure/tracheostomy (18%), and mortality (20.5%).

In a Japanese multicenter study, Imajo et al.[12] found a complication rate of 10.4% in patients with a mean age of 59.3 years in >30,000 spinal surgeries. In comparison, octogenarian patients older than 80 years are at higher risk for complications, with the rate increased by 2.7 times compared with patients of all ages. In the present series, this could be a reason for relatively low patient satisfaction postoperatively. Furthermore,

Table 1. Characteristics of the 39 Patients >80 Years of Age Undergoing Spinal Surgery for Traumatic Injury at Allegheny General Hospital (2011—2018)

Patient Characteristics	Incidence, % (n)	Median (Range)
Number of Patients		39
Sex		
Male	64 (25)	
Female	36 (14)	
Age (years)		83 (80—90)
Injury mechanism		
Falls	79 (31)	
Motor vehicle accident	13 (5)	
Fall from ladder	8 (3)	
Injury morphology		
Cervical injury	64 (25)	
Thoracolumbar injury	36 (14)	
Neurologic status (American Spinal Injury Association Scale)		
A	5 (2)	
B	8 (3)	
C	8 (3)	
D	33 (13)	
E	44 (17)	
Unknown*	3 (1)	
Spinal segments operated		3 (1—7)
Surgical approaches		
Posterior cervical fusion	39 (15)	
Posterior thoracolumbar fusion	21 (8)	
Anterior cervical fusion	18 (7)	
Posterior cervicothoracic fusion	10 (4)	
Posterior thoracic fusion	10 (4)	
Posterior lumbar fusion	3 (1)	
Mortality		
Inpatient	15 (6)	
90-day	21 (8)	
Discharge disposition		
Inpatient rehabilitation	38 (15)	
Senior nursing facility	18 (7)	
Long-term care facility	18 (7)	
Home	13 (5)	
Follow-up (months)		
Follow-up	59 (23)	4.5 (1—54)
Lost to follow-up (because of death or lost to follow-up)	41 (16)	
Medical comorbidities		
Hypertension	69 (27)	
Cardiac disease (coronary artery disease/ myocardial infarction/congestive heart failure)	67 (26)	
Diabetes mellitus	33 (13)	
Obesity	28 (11)	
Dementia	10 (4)	
Smoker	5 (2)	
Chronic kidney disease	5 (2)	
Cerebrovascular accident	3 (1)	
Cirrhosis	3 (1)	
Chronic obstructive pulmonary disease	3 (1)	
Injuries secondary to trauma		
Rib fracture	15 (6)	
Acute kidney injury	13 (5)	
Intracranial hemorrhage	10 (4)	
Pulmonary injury	8 (3)	
Significant soft tissue injury/hematoma	8 (3)	
Facial/head injury	5 (2)	
Shock/hemorrhage	5 (2)	
Vascular injury	3 (1)	
Myocardial infarction	3 (1)	
Intra-abdominal organ injury	3 (1)	
Pelvic fracture	3 (1)	
Major medical postoperative adverse events		
Major respiratory disorder (pneumonia, pneumothorax, hemothorax, pleural effusion, pulmonary edema)	31 (12)	
Significant cardiac event (myocardial infarction, cardiac arrest, major arrhythmia)	21 (8)	
Ventilator-dependent hypoxic respiratory failure	18 (7)	
Acute kidney injury	15 (6)	
Cardioversion/cardiac arrest	10 (4)	
Deep venous thrombosis/pulmonary embolus	10 (4)	
Ileus	8 (3)	
Pulmonary embolus	5 (2)	
Delirium	3 (1)	
Sepsis	3 (1)	

*Unknown neurologic status because of concurrent middle cerebral artery stroke resulting in a patient who was sedated and withdrawing to pain.

Table 2. Review of Medical Complications in 8 Previous Studies After Elective Spinal Surgery in Octogenarian Patients

Medical Complications	Patients (n)	Levels Operated	% Deep Venous Thrombosis/ Pulmonary Edema	% Myocardial Infarction/ Major Dysrhythmia	% Respiratory Disorder	% Sepsis	% Death	% Tracheostomy
Gerhart et al., 2018[8]	244	Lumbar	1.6	1.2	2.5	0	0	0
Kobayashi et al., 2017[13]	262	Cervical, 74; thoracic, 13; lumbar, 175	NA	NA	0.77	NA	0	NA
Rajpal et al., 2017[19]	95	Cervical, 39; lumbar, 56	6.3	6.3	3.2	21	8.4	1
Puvanesarajah et al., 2017[18]	5515	Cervical	1	1.2	6.2	NA	4.6	0.33
Saleh et al., 2017[20]	2320	Lumbar	1.7	0.52	NA	1	0.43	NA
Marbacher et al., 2016[15]	40	Lumbar	NA	NA	NA	NA	0	NA
Imajo et al., 2015[12]	346	NA	0.57	NA	1.7	NA	0.3	NA
Smith et al., 2008[21]	32	C2	6.3	21.9	0	NA	12.5	25

NA, not available.

age was found to be significantly associated with postoperative healing problems ($P = 0.021$) and major postoperative medical events ($P = 0.008$). For example, 4 of the 5 patients who presented with postoperative wound healing problems presented between the ages of 85 and 90 years and had 3–6 levels operated on during surgery. However, the number of levels operated on was not significant for wound breakdown or infection ($P = 0.11$). In addition, wound infection or dehiscence rates are similar in the trauma (5.1%) and the elective (0%–5%)[8,12,13,15,18-21] patient population (Table 3). The 4 patients presenting with wound issues postoperatively had no significant traumatic injuries associated with spinal trauma, were off the ventilator within 24 hours of surgery, and were mostly ambulatory and sent to inpatient rehabilitation.

Table 3. Review of Surgical Complications in 8 Previous Studies After Elective Spinal Surgery in Octogenarian Patients

Reference	Patients (n)	Levels Operated	% Epidural Hematoma	% Surgical Site Infections	% Durotomy	% Neurologic Injury	% Screw Malposition	% Hardware Failure
Gerhardt et al., 2018[8]	244	Lumbar	4.09836066	NA	18.0327869	0.40983607	NA	NA
Kobayashi et al., 2017[13]	262	Cervical, 74; thoracic, 13; lumbar, 175	2.7	2.7	NA	1.9 (2 C5 palsy; 3 transient weakness)	NA	NA
Rajpal et al., 2017[19]	95	Cervical, 39; lumbar, 56	3.1	5.3	5.3	NA	NA	1
Puvanesarajah et al., 2017[18]	5515	Cervical	NA	0.25	NA	0.24	NA	NA
Saleh et al., 2017[20]	2320	Lumbar	NA	1.42	NA	0.04	NA	NA
Marbacher et al., 2016[15]	40	Lumbar	2.5	0	10	0	0	2.5
Imajo et al., 2015[12]	346	NA	6.6	5.5	15.3	4.9	NA	NA
Smith et al., 2008[21]	32	C2	NA	3.1	NA	NA	NA	NA

NA, not available.

Mortality

Predictors for mortality in the postoperative period of spinal surgery include age as well as mechanical ventilation, cervical spine injury, and a high Injury Severity Score. Although age >35 years portends a greater risk of mortality,[29] Wilson et al.[27] found that patients younger than 70 years had an in-hospital mortality of 3.2%, whereas mortality for in-hospital patients older than 70 years was 27.7%. This finding is similar to the results of the present study, in which 10.3% of patients aged 80 years or older died compared with 5.5% of patients aged 18–79 years. In addition, age was significantly associated with early postoperative mortality ($P = 0.029$) in the present study, correlating with associated mortality in elderly populations for elective procedures. Looking at nonagenarian and centenarian patients, Hwabejire et al.[10] found that mechanical ventilation increased the odds of death by 6-fold, whereas in-hospital mortality of ventilated patients approached 50%. These data are supported by the present study because mortality in all 8 patients was related to hypoxic respiratory failure, with 7 of the 8 patients who died being respiratory dependent. In addition, the presence of cervical spine injury can result in a 4-fold increase in death, whereas a 1-unit increase in Injury Severity Score is correlated with a 9% increase in risk for death.[10]

Another risk factor that may influence mortality is the extent of the spinal fusion, or the number of instrumented spinal segments operated on during surgery. Although most elective spine operations in octogenarian patients involve only 1 intervertebral level, traumatic spinal injury operations typically span >1 spinal levels, with greater intraoperative blood loss, larger surgical wounds, and longer intubation times.[16] In our series, there was a statistically significant correlation between the number of levels operated on and the incidence of postoperative medical complications ($P = 0.035$). The correlation between the extent of spinal fusion and the withdrawal of care (comfort measures status), as well as the postoperative mortality, also approached significance ($P = 0.051$). Severe SCI on presentation causing paraplegia (ASIA A or B) was found to be a significant risk factor for withdrawal of care and early postoperative deaths ($P = 0.01$), but there was no clear association between postoperative mortality and the number of concomitant traumatic injuries.

Limitations

There are several limitations to this study, most prominently its retrospective nature. Because of transitioning to an electronic medical record in this period, paper records were sometimes lost or incomplete, preventing complete follow-up data from being collected for all patients. In addition, a lack of direct case controls, specifically relating to clinical outcomes of patients with nonoperative traumatic spinal injury, prevents a direct comparison of the efficacy of surgical intervention versus nonsurgical intervention for different types of traumatic spine injury. Other limitations include surgeons' selection bias, difficulty in identifying and separating some adverse inpatient medical events as postoperative complications versus sequelae of the original trauma, and a comparison of open procedure results with minimally invasive surgery procedure outcomes in a similar cohort. The limited number of patients in our series is underpowered to permit univariate and multivariate statistical analysis or effect size estimates and limits the statistical power in risk factor analysis for peroperative and postoperative complications.

CONCLUSIONS

Although the octogenarian population has increased risk for postoperative events after acute spinal injuries, surgical intervention for unstable injuries or for those requiring decompression for profound neurologic compromise may be worthwhile in the elderly population. Although direct surgical complication rates are not necessarily higher, medical risks are higher after surgery. Individualized discussion with patient and family is required to understand postoperative recovery and long-term mobility and functional expectations and should appropriately weigh these expectations against the surgical morbidity, mortality, and the natural history of their traumatic injuries.

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